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ORIGINAL ARTICLE

Survival after CABG – better than predicted by EuroSCORE and equal to the general population

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Abstract
Objectives. Examine short- and intermediate-term survival after coronary artery bypass grafting (CABG) and compare this to survival of the general population and to that predicted by EuroSCORE. *Design.* One thousand three hundred and fifty one consecutive patients undergoing CABG were prospectively included. Survival status was ascertained through the Norwegian National Registry. *Results*. Compared to the general population, no statistical significant difference in survival was seen in operated patients. Overall mortality rate was 0.8% after 30 days, 2.8%, 4.0% and 7.1% at one, two and three years, respectively. When patients were divided into four groups according to EuroSCORE, mortality increased significantly with increasing score, as expected. However, EuroSCORE overestimated mortality. *Conclusion.* Patients operated with CABG at our institution have similar survival as in the general Norwegian population. Although overestimating mortality by almost five-fold, we found a strong association between EuroSCORE and short-time survival, and an association between EuroSCORE and intermediate-term survival.

Key words: *CABG, EuroSCORE, survival obtained in studies of university hospital based heart failure management programs*

Given the high number of coronary artery bypass grafting (CABG) procedures worldwide, mortality-rate associated with the operation has a great impact on society. Low mortality-rate has been considered an important parameter suggesting high treatment-quality. However, highly specialized centers operating more complicated cases will normally have a higher mortality. A widely used method to predict per- and postoperative 30-days mortality associated with open heart surgery, is the EuroSCORE (1). This score is based upon a cohort of 19 030 consecutive adult patients undergoing cardiac surgery at 128 surgical centers in eight European states. Univariate and logistic regression analyses were used to identify significant preoperative risk factors predicting 30-days mortality. Comparison of EuroSCORE (i.e. predicted mortality) to actual 30-days mortality will give an estimate of the quality of the cardiac surgery performed in a specific institution. Furthermore, this ratio might also, to a certain degree, allow comparison between institutions. According to the registry of The Norwegian Association for Cardiothoracic Surgery (2), 30-days mortality after open heart surgery in Norway is lower than predicted by EuroSCORE. There might be several reasons for this. Increasing quality of the heart-surgery over the last years, a different cohort of patients compared to that originally used to calculate EuroSCORE, might be some of the explanation.

In addition to short-term survival compared to predicted mortality by EuroSCORE, intermediate- and long-term survival of patients undergoing CABG compared to that of the general population is also of great importance. Comparing survival between operated patients and the general population in different age groups might help guiding us in selecting patients for operation. Although this has been performed earlier in other countries (3–5),

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life-expectancy might differ markedly between countries and within a country over time. Thus, a continuous revision and report of such data gives valuable information to the decision making clinician.

The aim of the present study was, therefore, to determine the short- and intermediate-term survival among patients undergoing CABG at Ullevål University Hospital (UUH) and to compare the actual mortality to that predicted by EuroSCORE. Furthermore, we wanted to examine whether EuroSCORE could predict mortality beyond 30 days. We also wanted to compare survival of patients undergoing CABG surgery to that of the general population in Norway.

Our study is based on a cohort of patients operated consecutively at UUH from January 1, 2003 until December 31, 2006. Basic data of patients were registered prospectively in the hospital database and their survival status was established through the Norwegian National Registry (6).

Materials and methods

One thousand three hundred and fifty one patients operated consecutively for primary CABG, in the time period from January 1, 2003 to December 31, 2006, were included in the study. Patients undergoing additional surgery to CABG were excluded from the study. All patients were operated through a median sternotomy as previously described (7). Data, registered prospectively, were obtained from the hospital database and from patient files. Hypertension was defined as clinically recognized and under medical treatment. Smoking was defined as smoking until the month before operation.

The survival status as of December 31, 2006 was established through the Norwegian National Registry (6), and the collection of data was done at least three months after this date to ensure that all deaths of the study patients were registered. The endpoint was death from any cause. To compare patient-survival to the general population, patients were divided into 3 groups. Group 1 included patients from 0–59 years (n = 398), group 2 included patients from 60–69 years (n = 445) and group 3 included patients above the age of 70 years (n = 493). Eleven patients that had emigrated from the country and not been observed after December 31, 2006, were not included in the study as were four patients that could not be identified in the National Registry. Thus, a total of 1 336 patients underwent further analysis.

The calculated EuroSCORE number for a specific patient gives the additive percentage risk of dying within 30 days of a heart operation (Appendix 1). For example, an EuroSCORE of 1 predicts a one percent risk of dying in hospital or within the first 30 postoperative days. Our patients were divided into groups according to EuroSCORE as calculated by Appendix 1. The groups were divided based on the need to account for enough patients in each group to make statistical analyses. Groups were defined as follows: Group 1: (n = 325) EuroSCORE 1-2, group 2: (n = 386) EuroSCORE 3-4, group 3: (n = 277) EuroSCORE 5-6 and group 4: (n = 177) EuroSCORE 7 and above.

Data concerning measurements of Ck-mb and Troponin-T was retrieved from the patient database at Ullevål University Hospital. Serum levels of both Ck-mb and Troponin-T were all measured by the Department of Clinical Chemistry as previously described (8). Ck-mb and Troponin-T values were routinely measured preoperatively and 7 hours, 20 hours, and 44 hours postoperatively.

Statistical analysis

Data from continuous variables are presented as mean and standard deviation, and data from binary variables are presented as percentages. Adjusted and unadjusted associations between background variables and mortality were investigated by means of the proportional-hazards model (9). Results from such analysis are presented as hazard rates (HR) with 95% confidence intervals (CI). For a continuous variable the presented HR may be interpreted as the relative increase in mortality when the variable increases one standard deviation. Thus, if HR for creatinin equals 1.16, this implies that mortality increases with 16% when creatinin increases by one standard deviation. For a binary variable with score 'yes' or 'no', the presented HR may be interpreted as the mortality in the 'yes' group divided by the mortality in the 'no' group.

Kaplan-Meier curves were used to estimate mortality after 30 days, and after 1, 2 and 3 years in our CABG study. Data from Statistics Norway (6) were used to estimate age-, gender- and time period-matched mortality after 1, 2, and 3 years in the general population of Norway.

In order to decide whether a mortality curve from the CABG study differs significantly from a corresponding mortality curve from the general population, a standardized mortality rate with 95% confidence interval was calculated.

The assumptions of the proportional-hazards model were checked for each model, and found to be adequately met. The models were computed with the use of Statistical Package for the Social Sciences (SPSS) version 14.0.

Results

Patient characteristics

Table I shows baseline characteristics of the patients in our cohort. The mean age was 65 years and 19% of the patients were women. Two hundred and forty one of the patients were followed more than 3 years, 606 more than 2 years, 971 more than 1 year and 1 306 more than 30 days. Variables predicting mortality in our patient cohort are shown in the table with the corresponding HR and p-value.

Short- and intermediate-term survival

In Figure 1 the patient population is divided into three groups according to age. We have compared the survival of the operated patients to that of the general Norwegian population in the same age group as reported by the Norwegian National Statistical Registry. In group 1, patients were from 0–59 years old with a mean age of 53 years (356 men and 42 women). One year survival was 99.1%, two years survival 99.1% and three years survival 97.2%. In group 2 patients ranged from 60-69 years with a mean age of 65 years (363 men and 82 women). Group 2 showed a one year survival of 98.8%, two years survival of 98.1% and three years survival of 95.6%. In group 3 the patients were from 70 years and older with a mean age of 75 years (366 men and 127 women). Group 3 had a one year survival of 94.3%, two years survival of 91.6% and three years survival of 86.2%. Compared to the general Norwegian population, we did not find any statistical significant different survival of operated patients at one, two and three years. However, there was a tendency in group 2 of a better survival in the patient population. Thirty days mortality was 0% in group 1 and 2 and 2% in group 3. The overall mortality rate in our cohort was 0.8% at 30 days, 2.8% at one year, 4.0% at two years, and 7.1% at three years.

EuroSCORE and mortality

The association between EuroSCORE and mortality is shown in Figure 2. Although meant for prediction of 30-days mortality, we have extended the prediction up to three years. The patients were divided into four groups. The first group (n = 325) included those with EuroSCORE 1-2. They had a 30-days mortality of 0%, one year mortality of 0.4%, two years mortality 0.4% and three years mortality of 0.4%. We used the first group as reference and sat HR as 1. The second group (n = 386) included patients with EuroSCORE 3–4. They had a 30-days mortality 0.8%, one year mortality of 2.0%, two years mortality of 3.2% and three years mortality of 7.0%. Compared to the first group HR was 13 (CI 1-101, p = 0.012), i.e. mortality was significantly higher in group 2 than in group 1. The third group (n = 277) included patients with EuroSCORE 5–6.

Table I. Demographic and cardiac variables. Analyses are presented as hazard rates (HR) with 95% confidence intervals (CI). S.D. = Standard deviation, NYHA = New York Heart Association, COPD = chronic obstructive pulmonary disease, EF = ejection fraction, CPB time = cardiopulmonary bypass time.

Variable		p-value	HR (95% CI)
Demographic variables			
Age (mean ± S.D.)	65.0 ± 10.0	<0.001	1.09 (1.06-1.13)
Female (%)	18.8	0.106	1.59 (0.91–2.77)
NYHA (mean ± S.D.)	2.8 ± 0.8	n.s.	0.94 (0.70–1.26)
COPD (%)	6.4	n.s	1.66 (0.72–3.86)
Renal failure (%)	1.3	<0.002	4.99 (1.81–13.7)
Creatinin preop., mg/dl (mean ± S.D.)	89.6 ± 53.0	<0.001	1.16 (1.07–1.25)
Creatinin 2 days postop., mg/dl (mean ± S.D.)	86.0 ± 53.0	<0.001	1.28 (1.17–1.39)
EF (%, mean ± S.D.)	60.2 ± 15.3	<0.002	0.69 (0.55–0.87)
Diabetes (%)	15.9	n.s.	1.17 (0.61–2.24)
Apoplexia cerebri (%)	19	n.s.	0.93 (0.13–6.67)
Emergency (%)	3.6	n.s.	1.28 (0.40–4.11)
CPB time, minutes (mean ± S.D.)	75.5 ± 22.2	n.s.	1.12 (0.88–1.42)
EuroSCORE (mean ± S.D.)	3.6 ± 2.5	<0.001	1.33 (1.23–1.44)
Hypertension (%)	41.4	0.071	1.58 (0.96–2.60)
Smoking (%)	27.3	n.s.	1.21 (0.71–2.08)
Extracardiac arteriopathy (%)	9.4	<0.001	4.08 (2.36–7.07)
Cardiac variables			
Unstable angina (%)	1.8	n.s.	1.49 (0.36–6.11)
Distal anastomosis (mean ± S.D.)	3.1 ± 0.9	n.s.	1.09 (0.83–1.44)
Previous myocardial infarction (%)	35.6	n.s.	1.35 (0.81–2.23)
Occlution time, minutes (mean ± S.D.)	38.9 ± 13.6	n.s.	0.86 (0.77–1.25)
Ck-mb max (mean ± S.D.)	36.6 ± 38.4	0.002	1.22 (1.08–1.38)
Troponin-T max (mean ± S.D.)	0.74 ± 0.9	<0.001	1.40 (1.29–1.53)

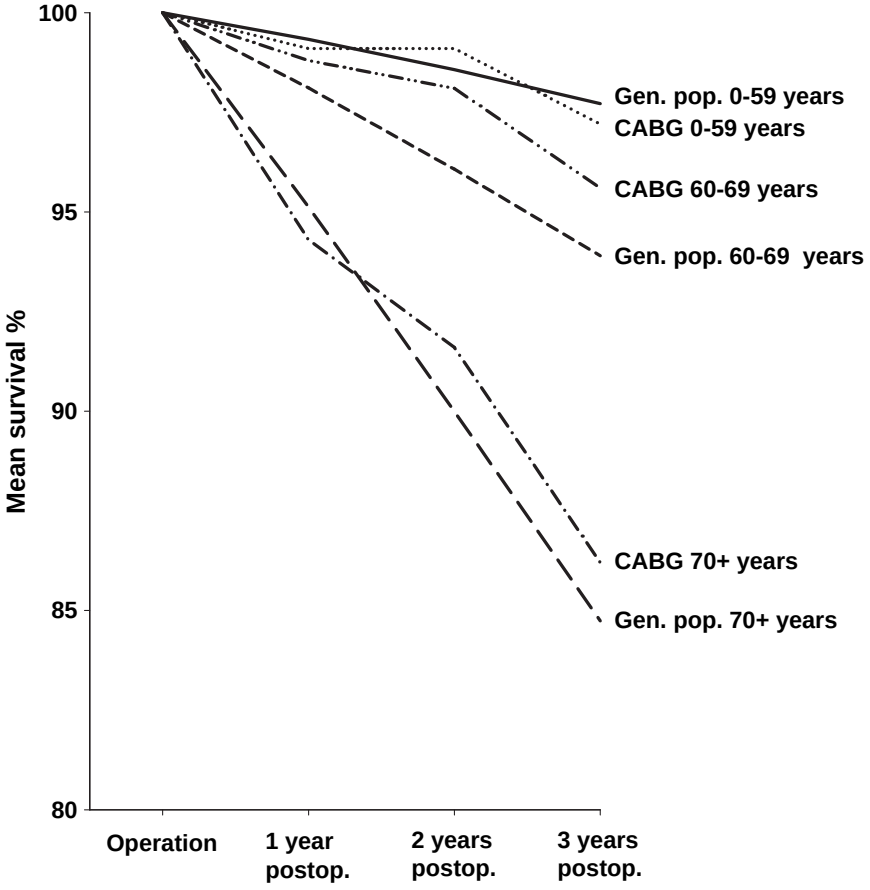

Figure 1. Kaplan-Meier estimate of unadjusted survival showing 3 years survival after coronary artery bypass surgery. Survival curves for the general Norwegian population (Gen. pop.) are shown for comparison. CABG = coronary artery bypass grafting, postop. = postoperatively.

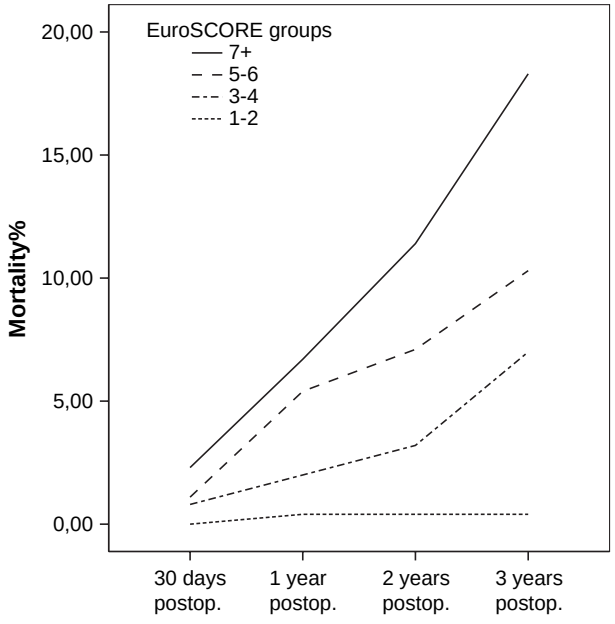

Figure 2. Kaplan-Meier mortality curve, showing mortality during 3 years postoperative (postop.) follow-up according to EuroSCORE.

They had a 30-days mortality of 1.1%, one year mortality of 5.4%, two years mortality of 7.1% and three years mortality of 10.3%. Compared to the first group HR was 24 (CI 3-176, $p = 0.002$). The fourth group ($n = 177$) included patients with EuroSCORE 7 and higher. The 30-days mortality was 2.3%, one year mortality 6.7%, two years mortality 10.4% and three years mortality was 18.3%. When compared to the first group HR was 40 (CI 5-299, $p < 0.001$).

Discussion

The present study shows that survival up to three years postoperatively following CABG is at least as high as in the general Norwegian population. A tendency to higher survival was found in patients between 60 and 69 years old. Thirty days mortality was 0.8% in the present study whereas predicted mortality according to EuroSCORE was 3.6%. EuroSCORE might be used to predict mortality also beyond 30 days postoperatively.

Our statistical analysis showed that age, EF, preoperative renal failure, high levels of creatinine two days postoperatively, smoking when adjusted for

age and gender, Ck-mb and Troponin-T are all single variables that may be used to predict mortality. Myers and co-workers (10) evaluated 8221 patients operated by CABG in the Coronary Artery Study (CASS) registry, with a mean follow-up of 15 years. Heavier weight, prior myocardial infarction, diabetes, and smoking were all associated with increased late mortality (3,10). Although the same factors did not reach statistical significant in our study, the tendency was still there. Surprisingly, neither diabetes nor previous myocardial infarction turned out to be statistical significant predictors of survival during 3 years. It is, however, possible that these factors will reach statistical significance if the patients in our study had been followed for another 12 years. In our cohort we have not discriminated between cardiac and non-cardiac death, since our study was strictly designed to measure overall survival. Herlitz and co-workers followed 2000 patients for 13 years after CABG and found that the most frequent cause of death was heart failure followed by myocardial infarction (11). Factors found to be associated with increased risk of cardiac death included high age, current smoking, history of myocardial infarction, hypertension, and diabetes.

The present study shows that survival among patients operated with CABG in our hospital is the same, or even shows a tendency to be better, as in the general Norwegian population. There might be several reasons for this finding. Patients offered an operation for coronary artery disease represents a selected group fit enough to be eligible for a major surgical procedure. Thus, especially in the older patient groups, patients with severe co-morbidities or cancer with short life-expectancy will not be offered CABG. A lack of such patients in the cohort operated with CABG compared to the prevalence of such patients in the general Norwegian population might in part explain the findings of the present study. Another point is of course that patients in the present study are treated for a potentially deadly disease with a treatment (CABG) documented to reduce mortality. In the general Norwegian population there might be patients with asymptomatic coronary artery disease or patients too sick to be offered an operation which might increase mortality in this specific group. However, if our patients are followed for a longer period of time, the cardiovascular disease might evolve and result in an unfavorable outcome for CABG patients compared to the general population in a longer perspective.

Our study showed a strong association between EuroSCORE and short-term survival. However, EuroSCORE in our cohort of patients predicted almost five times the mortality that was actually found according to the National Registry (6). These findings are in accordance with those recently reported by Mølstad from the Feiring Clinic (12). Several factors might explain this finding. EuroSCORE was established in a study analyzing patients undergoing CABG in 1995 (1). First, most likely, there has been an improved quality over the years both regarding surgery, preoperative and postoperative care. At our institution, specifically, we have introduced an intermediate ward ("step down") between the postoperative unit and the regular ward. This intermediate ward has a better surveillance of the patients compared to a regular ward and offers respiratory support by skilled personnel, such as continuous positive airway pressure (CPAP), when needed. Instead of being sent directly to a regular ward the first postoperative day, patients will normally stay 2-4 days in the intermediate ward before being sent to the regular ward or to a local hospital. It should also be noted that we have dedicated anesthesiologists and operating nurses allocated to our department only. Secondly, the cohort of patients operated in Norway and in our department might differ from that of the EuroSCORE study. There are obvious risk factors that are not detected by the EuroSCORE system, such as heavy calcification of the aorta and of the peripheral coronary arteries. Moreover, EuroSCORE includes both patients who dies within 30 days postoperatively and after 30 days but within the same hospital stay. However, no registry in Norway allows us to exactly register in hospital-mortality of patients surviving the first 30 postoperative days, although this is most likely a limited number of patients. Another point is that the EuroSCORE itself might reduce mortality in that it allows us to identify the high risk patients before surgery and may contribute to improvements in peroperative strategy and postoperative care. The mortality rate increases at all the different time-points in each EuroSCORE-group suggesting an association between EuroSCORE and intermediate-term survival. It should be noted, however, that few patients were followed for as long as three years. The limited number of patients in the present study does not allow a multivariate analysis with the same power as that performed in the original EuroSCORE calculation. Thus, the association between EuroSCORE and intermediate-term survival needs to be confirmed in a larger cohort of patients to be able to correlate intermediate-term survival to the specific preoperative variables used in the original EuroSCORE-calculation.

In conclusion, the present study shows that survival up to three years postoperatively following CABG is at least as high as in the general Norwegian population. Thirty days mortality in our cohort of patients was 0.8%, whereas that predicted by

EuroSCORE was 3.6%. Nevertheless, our study showed that EuroSCORE might also be used to predict mortality beyond 30 days postoperatively.

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Appendix

Taken from http://www.euroscore.org/euroscore_scoring.htm.

		Score
Patient-related factors		
Age	(per 5 years or part thereof over 60 years)	1
Sex	female	1
Chronic pulmonary disease	longterm use of bronchodilators or steroids for lung disease	1
Extracardiac arteriopathy	any one or more of the following: claudication, carotid occlusion or >50% stenosis, previous or planned intervention on the abdominal aorta, limb arteries or carotids	2
Neurological dysfunction disease	severely affecting ambulation or day-to-day functioning	2
Previous cardiac surgery	requiring opening of the pericardium	3
Serum creatinine	>200m micromol/L preoperatively	2
Active endocarditis	patient still under antibiotic treatment for endocarditis at the time of surgery	3
Critical preoperative state	any one or more of the following: ventricular tachycardia or fibrillation or aborted sudden death, preoperative cardiac massage, preoperative ventilation before arrival in the anaesthetic room, preoperative inotropic support, intraaortic balloon counterpulsation or preoperative acute renal failure (anuria or oliguria <10 ml/hour)	3
Cardiac-related factors		
Unstable angina	rest angina requiring iv nitrates until arrival in the anaesthetic room	2
LV dysfunction	moderate or LVEF30-50%	1
	poor or LVEF <30	3
Recent myocardial infarct	(<90 days)	2
Pulmonary hypertension	Systolic PA pressure >60 mmHg	2
Operation-related factors		
Emergency	carried out on referral before the beginning of the next working day	2
Other than isolated CABG	major cardiac procedure other than or in addition to CABG	2
Surgery on thoracic aorta	for disorder of ascending, arch or descending aorta	3
Postinfarction septal rupture		4